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Ecology of the large indigenous earthworm *Megascolex imparicystis* in relation to agriculture near Lancelin, Western Australia

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Abstract

The largest species of earthworm known in Western Australia was studied in agricultural soils near Lancelin. In pasture its frequency of occurrence in quadrats, density and biomass (fresh weight) were 18-20%, 5.0-5.5 m^{-2} and 41-67 gm^{-2} respectively. Although indigenous, we failed to find it in soil under nearby native heath ("sandplain") or in soil from which native vegetation had recently been removed. Despite virgin and recently cleared soils differing from pasture soils principally in extractable P and N, earthworms cultivated in virgin and pasture soils in the laboratory showed no differences in survival or weight over 50 days. Ploughing of pasture did not cause an immediate reduction in density, but one year later (and after a second ploughing) density averaged 1.1 m^{-2}.

Introduction

Much of the agriculturally-developed land of Western Australia is occupied by two species of earthworm of European origin (Abbott and Parker 1980). However, in 1980 Dr. D. L. Chatel drew our attention to an abundant population of a large earthworm (up to 30cm in length) captured by the tynes of a cultivator on a farm adjacent to Karakin Lake, 100 km NW of Perth. According to Mr. J. Wood, owner of "Karakin" farm, these large earthworms were present when native vegetation was cleared for agriculture in 1958. This earthworm proved to be the indigenous species *Megascolex imparicystis* Michaelsen 1907, which occurs between Dongara, Dandaragan and Perth (Abbott 1982).

We aimed to determine the density and biomass of this species in virgin and agriculturally-developed soils, and to explain why a population of a native species of earthworm could persist in agricultural soil. A previous survey (Abbott and Parker 1980) had shown that no native species occurred in agricultural soils of the wheatbelt of Western Australia, although several native species have been recorded in soils under native vegetation at Jilakin Rock and near Wongan Hills and Hyden (Abbott, Parker and Milewski, pers. obs.).

Study area and methods

In 1981 and 1982 we sampled quantitatively earthworm populations on pasture, recently ploughed pasture, virgin heathland and recently cleared heathland. Soils from each area were collected and characterized for selected physical and chemical properties.

Environment

The study area lies on the Karrakatta landform unit (Churchward and McArthur 1980), which consists of deep sands overlying aeolianite. In places limestone is exposed at the soil surface. These soils are infertile because of their great age and the strong leaching action of heavy winter rains on their porous sandy surfaces (Bettenay *et al.* 1960). Although P is essential for the establishment and maintenance of pastures, it is not the only factor limiting growth, as Cu and Zn deficiencies are important especially after superphosphate has been added (Bettenay *et al.* 1960).

The climate of the study area is typically Mediterranean, with hot, dry summers and cool, wet winters. At nearby Lancelin, the average annual rainfall is 627 mm, with nearly half falling in June and July.

The whole area was virgin heath and woodland until 1958. Vegetation present on the virgin study site is heath up to 4 m tall. Principal species are *Banksia attenuata, B. sphaerocarpa, Dryandra sessilis, Hakea* sp., *Calothamnus* sp., *Eucalyptus todtiana, Xanthorrhoea preissii, Nuytsia floribunda,* and *Allocasuarina humilis.* The recently cleared site has a few individuals of *Macrozamia riedlei, N. floribunda, X. preissii* and *Eucalyptus decipiens.* It was cleared by chaining in July 1979, and burning in March 1980, planted with an oat crop in June 1980, grazed by sheep and then planted with another oat crop in 1981. The pasture site has a few clumps of *Eucalyptus todtiana, E. gomphocephala* and *E. decipiens* remaining, but is sown to Serradella (*Ornithopus sativa*) and Subterranean Clover (*Trifolium subterraneum*). In June 1981 it had been last ploughed 6-7 years previously. Since 1958, the pasture has received superphosphate and trace elements including Mn, Zn, Co and Cu. The recently ploughed site was sampled six days after ploughing in June 1981. It was then seeded with oats with a combine seeder, superphosphate being added also. In 1982 it was reseeded with lupins. All sites are within 1km of each other.

Field observations

Fifty soil samples (19 x 19 x 29 cm depth) were randomly extracted by spade from each of the four sites in June 1981 and 1982. This soil was sorted by hand for earthworms, which were taken to the laboratory for weighing. Earthworms were also collected from tynes of the cultivator in order to determine mean weight of a larger sample.

Soil analyses

Soils were analysed for % gravel, coarse sand, fine sand, silt and clay (pipette method, Piper 1947), soil moisture (gravimetrically determined), pH (5:1 w/v water:soil), organic carbon (Walkley-Black, see Piper 1947), Total N (Kjeldahl method, see Piper 1947), extractable N (Purvis and Leo 1961), Total P (Murphy and Riley 1962), extractable P (Watanabe and Olsen 1965) and total K (HCl digest, see Piper 1947).

Laboratory experiment

A completely random design of two treatments (pasture soil, virgin soil) with five replicates was followed. The soils were obtained from the surface 15 cm of the pasture and virgin heath sites, air dried, and passed through a 1.96 mm sieve. Five lots of 5 kg each of virgin soil and pasture soil were placed in plastic pots (diameter 20.5 cm) lined with plastic bags. The depth of soil was 25 cm. The water holding capacity of the soils was determined and the soils in each pot maintained at 60% water holding capacity (Piper 1947). Pots were left to stand in the laboratory for four weeks before the addition of earthworms. Earthworms were collected from the top 20 cm of soil close to Karakin Homestead and were selected to have similar weight. One worm was added to each pot. Worms were weighed (Abbott and Parker 1981) every ten days for 50 days.

Results

Fresh weight of Megascolex impariсystis

In June 1981, 52 apparently undamaged earthworms were collected from the ploughed paddock. Mean weight (± SE) was 8.21 ± 0.40 g, with range of 2.74-16.0 g. The frequency distribution of weights was:

weight (g)	2-5.9	6-9.9	10-13.9	14-16
N	10	26	15	1
%	19	50	29	2

Mean weight of the June 1982 sample, collected from more fertile soil adjacent to the Homestead, was 12.2 ± 1.4 g (N=19), range 6.7-18.4 g with one individual weighing 27.4 g. Mean weights of undamaged specimens collected from the soil samples in the pasture were 4.5 g (N=8) in 1981 and 6.3 g (N=6) in 1982. These, however, are probably under-estimates of the true means because larger individuals tend to be cut into fragments during the extraction of the soil core. The method of obtaining worms from tynes would tend to miss smaller individuals and bruise larger ones.

Table 1

Frequency, density and biomass (fresh weight) of *Megascolex impariсystis* in the four sites studied

Site	Frequency (%)	Density (m^{-2})	Biomass (gm^{-2})
Virgin	0(0)	0(0)	NA
Recently cleared	0(0)	0(0)	NA
Pasture.....	18(20)	5.0(5.5)	41.1(67.1)
Recently ploughed..	16(4)	4.4(1.1)	36.1(13.4)

NA, not applicable

In each column, the 1981 figure is presented first, with the 1982 figure in parentheses.

Frequency, density and biomass

In both years no earthworms were found in the virgin or recently cleared sites (Table 1). In 1981 the frequency of occurrence of earthworms in pasture was similar to that in the recently ploughed pasture, but the latter declined by June 1982. The density and biomass of earthworms in 1982 in the recently ploughed pasture was also less than in 1981 (Table 1).

Physical and chemical characteristics of soil

Of the features examined (Table 2), extractable N was greatest in pasture and extractable and total P were greatest in both pasture and recently ploughed pasture.

Laboratory experiment

In both treatments worms showed an increase in weight over the first ten days (Table 3). However at no time during the experiment was there any significant difference in mean weight between earthworms in virgin or pasture soil.

Discussion

The lack of significant differences in weight between earthworms cultivated in virgin and pasture soil in the laboratory indicated that soil differences in extractable P and N do not affect the growth of *Megascolex impariсystis*. But paradoxically, the field investigations showed that no earthworms were recorded in virgin soil or recently cleared soil. Without the laboratory experiment the obvious conclusion was that this species of native earthworm benefited from increases in extractable N and P (and possible trace elements) in pasture soils. The difficulty of sampling around tree roots in virgin soils may have biassed the sampling. If earthworms fed close to roots, they may not have been detected. However, this factor should not have been important in the recently-cleared site. Because of the farmer's observation of the occurrence of this species before farming began, we conclude that *Megascolex impariсystis* is very sparsely distributed in virgin soils.

It is uncertain whether growth rates in pots would be the same as in natural soil, but it would be almost impossible at this stage to do growth experiments in the field because these earthworms are known to burrow down to at least 4 m.

In the virgin soil the food resources would be derived from the partial decomposition of leaf and root material from the native plant community. In the pasture soil, where the earthworms are quite numerous, it must be assumed that the organic matter derived from subterranean clover and sheep manure is the chief source of food.

The biomass of *Megascolex impariсystis* in pasture ranged from 40-70gm^{-2}, i.e. 400-700 kg ha^{-1}. This is about 2-3 times that of the sheep on the same pasture (stocking rate averages 4 ha^{-1}, J. Wood, pers. comm.). This earthworm biomass is similar to that obtained in pastures elsewhere in Western Australia (McCredie 1982, I. Abbott, unpubl.).

Table 2

Physical and chemical characteristics of the soil at the four sites studied

Feature	Virgin		Recently cleared		Pasture		Pasture recently ploughed	
Soil moisture (%)	7.1	(—)	8.4	(—)	9.9	(—)	—	(—)
Gravel (%)	5.6	(—)	7.3	(—)	9.3	(—)	4.9	(—)
Coarse sand (%)	86.5	(—)	79.6	(—)	84.9	(88.2)	88.6	(—)
Fine sand (%)	10.0	(—)	14.7	(—)	1.1	(6.9)	0.1	(—)
Silt + clay (%)	3.5	(—)	5.7	(—)	14.0	(5.6)	11.3	(—)
pH	5.94	(6.25)	6.66	(6.31)	6.38	(5.90)	6.00	(5.83)
Organic C (%)	0.98	(0.75)	1.39	(1.10)	0.86	(0.81)	0.90	(0.97)
Total N (%)	0.054	(0.030)	0.056	(0.060)	0.056	(0.056)	0.060	(0.043)
Extract. N (ug g^{-1})	—	(58)	—	(58)	—	(72)	—	(56)
Total P (ug g^{-1})	26	(20)	22	(35)	50	(79)	56	(55)
Extract. P (ug g^{-1})	—	(3.3	—	(2.3)	—	(5.3)	—	(6.2)
Total K (Me/100g)	0.17	(0.13)	0.17	(0.15)	0.22	(0.15)	0.12	(0.12)

— not determined

In each column, the 1981 figure is presented first, with the 1982 figure in parentheses

Table 3

Mean weight in grams (± 95% confidence interval) of *Megascolex imparicystis* cultured for 50 days in virgin and pasture soils from near Lancelin

Soil type	Time (days)					
	0	10	20	30	40	50
Virgin	1.43	2.12	2.27	2.25	2.41	2.27
	(0.31)	(0.43)	(0.47)	(0.53)	(0.45)	(0.43)
Pasture	1.44	2.07	2.05	2.13	2.00	2.03
	(0.33)	(0.53)	(0.45)	(0.41)	(0.37)	(0.39)

Of interest is the absence from this pasture of *Aporrectodea* (=*Allolobophora*) *trapezoides* and *Microscolex dubius*. Both species are widespread in agricultural areas of Western Australia (Abbott and Parder 1980); however, they occur at "Karakin" only in the homestead garden and around the sheepyards. It is not known if these species are excluded from the pasture through competition with *Megascolex imparicystis* or have not had time to occupy this land.

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